

## 10.12 BCD Proposal: Longitudinal Diagnostics System

### 1. Overview

The purpose of the longitudinal diagnostics is 1) qualify the beam at the extraction of the damping ring, 2) determine the performance of the bunch compressor system and 3) measure correlations between directions in phase space ( $x$   $z$ ,  $y$   $z$ ,  $E$   $z$ ). The required resolution is set by the feature size in the bunch longitudinal distribution, which is typically not Gaussian.

The longitudinal beam size monitors will also be used to measure the energy spread. The resolution should be a fraction (20%) of the nominal energy spread. This will typically be done with wire scanners or laserwires at regions of high dispersion. For simplicity these are known as energy spread wires. Energy spread wire locations

- 1) Source capture beam
- 2) Damping ring entrance
- 3) Damping ring exit
- 4) Linac entrance
- 5) Linac exit (and undulator entrance if different)

### 2. Baseline Configuration

#### a. Description

There will be 4 longitudinal diagnostic systems in the damped beam regions (per side),

- 1) at the exit of the damping ring
- 2) at the exit of the bunch compressor
- 3) at the exit of the main linac
- 4) near the IP. This can be integrated with the crab system and should be focused on measurement of the  $y$   $z$  correlation ‘banana effect’.

Typical performance requirements are to resolve structure which is a fraction of the bunch length, about 20% or 30 microns.

In the injector system, there is a similar set of requirements to monitor the phase space of the beam to be injected in the damping ring, the damping process and the capture process.

- 1) at the exit of the sub-harmonic buncher
- 2) at the entrance to the damping ring
- 3) in the damping rings themselves
- 4) after the capture RF.

Typical performance requirements is to have resolution of about 150 microns. Excellent demonstrations of the use of two dimensional deflecting structures have recently been completed. These facilitate buncher and related low-velocity beam tuning.

The above systems, as with the transverse systems, work best if properly integrated into the surrounding lattice. This may have cost impact.

There are several longitudinal diagnostic systems under development for use at FEL's.

- 1) high power RF deflecting structures (LOLA, or crab structures) [1]

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- 2) electro-optical sampling [2]
- 3) coherent radiation (synchrotron, diffraction, Smith-Purcell) [3]
- 4) ultra-fast laser wire [4]

The BCD should have 1), high power RF deflecting structures, in each of the above listed locations. The RF deflecting structure provides a ‘z-dependent’ kick that allows the longitudinal structure of the beam to be imaged. The direction perpendicular to the kick shows the correlation. This device is the only one of the four techniques listed which has demonstrated excellent correlation measurements. Since the correlation information is 2 dimensional, they work best with video imaging, and not with sampling (laserwire) like systems. RD is needed to make sure that reliable, durable video imaging can work with low emittance, high energy ILC beams. In the BCD, the deflecting structure is a warm copper structure capable only of deflecting a single bunch, but with very high gradient. The BCD structure is either 2600 or 3900 MHz.

### b. Supporting Documentation

Paper on LOLA systems at SLAC and TTF:

<http://www.slac.stanford.edu/cgi-wrap/getdoc/slac-pub-9241.pdf>

[http://docdb.fnal.gov/ILC/DocDB/0001/000108/001/lolafel2005\\_version05081701.pdf](http://docdb.fnal.gov/ILC/DocDB/0001/000108/001/lolafel2005_version05081701.pdf)

Paper on use of a two dimensional LOLA structure by Jake Haimson of Haimson Research Corp. ‘Longitudinal Phase Space Measurements of Short Electron Bunches Using a 17 GHz Circularly Polarized Beam Deflector’, Advanced Accelerator Concepts Workshop, AIP Conference Proceedings 737, 2004.

Very high resolution OTR studies done at ATF, J. Frisch et al.,  
<http://atfweb.kek.jp/atf/Reports/ATF-01-08.pdf>

### c. Required Research and Development

RD is required to show:

- 1) performance of very high resolution two dimensional imagers for use with micron-sized damped beams. Present state of the art demonstrations have shown two micron minimum feature resolution.
- 2) operation of warm structure LOLA systems in the low emittance transport system
- 3) structures with the capability of switching between x and y deflections, or structure pairs with both kicks – 90 degrees out of phase
- 4) integrated performance of fast non-invasive bunch length monitors – calibrated using the LOLA type devices.

## 3. Alternative lower cost Configuration

### a. Description